The Marine Laboratory
UNIVERSITY OF MIAMI

59-6

THE CHARLES F. JOHNSON OCEANIC GAME FISH INVESTIGATIONS

Progress Report No. 6

SUMMARY OF INVESTIGATIONS FOR
THE PERIOD COMPRISING
NOVEMBER 1958 THROUGH DECEMBER 1959

by

C. RICHARD ROBINS

MIAMI 49, FLORIDA

THE CHARLES F. JOHNSON FOUNDATION

THE INTERNATIONAL OCEANOGRAPHIC FOUNDATION

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THE MARINE LABORATORY
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Miami 49,
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F. G. Walton Smith,
Director

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INTRODUCTION

Work during the period November 1958 through December 1959 on oceanic gamefishes may be divided as follows:

1. Preparation for and running of The Fourth International Gamefish Conference at Nassau on November 10 and 11, 1959.

2. Supervision of a research assistant who analyzed data gathered in previous years.

3. Field research on the blue marlin in Hawaiian waters.

4. Preparation of manuscript on spearfishes.

5. Work of the I.O.F. Gamefish Committee.

1. The Fourth International Gamefish Conference was held on November 10th and 11th at the British Colonial Hotel. The following program was presented:

November 10	Morning Session
Chairman	C. Richard Robins The Marine Laboratory University of Miami
1. Tarpon Research During the 1958-59 Season	Richard B. Wade The Marine Laboratory University of Miami
2. Fishing in Bahamian Waters	Stafford Sands The Development Board Nassau
3. Blue Marlin in the Atlantic and Pacific: Confusion More Confounded	James E. Morrow Bingham Oceanographic Laboratory, Yale University
4. Development of Blue Marlin and Billfishing in the Waters off Cape Hatteras, North Carolina	Aycock Brown Dare County Tourist Bureau Manteo, North Carolina

5.	Pollution and the Marine Environment	Fritz Mangold Sports Council, Inc. Temple City, California
6.	Tarpon Fishing in Virginia	Melvin L. Shreves Salt Water Sports Fishing Association of Virginia
7.	Sport and Commercial Fisheries Potential of the Virgin Islands National Park	John E. Randall and C. P. Idyll The Marine Laboratory University of Miami
8.	The White Marlin Fishery in Middle Atlantic Waters	Donald P. deSylva Bayside Laboratory University of Delaware

November 10 — Afternoon Session

Discussion Leader — Daniel H. Janzen, Director, Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Washington, D. C.

November 11 — Evening Session

1.	A Cruise to Tahiti (16 mm. color film)	John E. Randall The Marine Laboratory University of Miami
2.	A Survey of the Exuma Cays Land-and-Sea Park (16 mm. color film)	Carleton Ray New York Aquarium

A luncheon was held by Dr. F. G. Walton Smith to discuss the future aims of The Conference. James E. Böhlke, Charles C. G. Chaplin, Donald P. deSylva, Daniel H. Janzen, Edward C. Raney, C. Richard Robins, Paul E. Thompson and Gilbert L. Voss attended.

The proceedings of The Conference have been assembled and should be multilithed and distributed early in 1960.

2. Mr. Jay Ewald was employed from June 15 to September 15, 1959 to analyze data obtained on billfishes in past years. All measurements have been converted to percentage of body length. Regressions of absolute length of body parts against body length have been completed for some features that showed marked allometry. In addition Mr. Ewald measured additional specimens of white and blue marlin and Atlantic sailfish. Again Al Pflueger has been a valued source of information and material.

3. Through a generous grant by Mr. Morton B. May, Dr. Robins was able to go to Hawaii during the month of August. A stormy period that ended just before the start of this work had kept most boats in port and few fish were caught the first week. In all, however nearly 50 marlin were examined. Three were striped marlin, one was a black and the remaining were blue marlin. Fish were examined both in Kona on the island of Hawaii and at Honolulu. Most were seen at Otanis fish market.

Of special value was the opportunity to examine a size series of blue marlin. In the past comparisons of Pacific and Atlantic have suffered because of the large size of those caught in the Pacific. (The same maximum weight is indicated for both regions). Supposed differences between Pacific and Atlantic blue marlins are due to changes in growth. Many ichthyologists including the writer have been mislead by comparing specimens of different sizes. The writer, as a result of this summers work considers the blue marlin, Makaira nigricans, as one worldwide species.

Our current knowledge suggests that there are but three marlins, striped, black, and blue, in the Indo-Pacific and that the so-called silver marlin does not exist, the name being applied depending on the region and the fisherman to all three species. It is recommended that silver marlin entry be dropped from the IGFA records.

Several blue marlin examined at Kona were nearly ripe females and one male was running milt. The Hawaiian study was very worthwhile and results obtained will aid the Laboratory's program in many ways. The writer takes this opportunity to acknowledge the support of Mr. May.

On the return trip, stops were made at the California Academy of Sciences and the Stanford Natural History Museums. Old photographs, some mounted specimens (several of them types), and several skeletons were examined. This information will be of aid in correctly allocating the records of Jordan Evermanns, for the material is part of the basis of their 1926 paper on giant fishes.

4. Dr. deSylva and the writer finished a rough draft of the manuscript on Atlantic spearfishes. A considerable amount of time has been put into this manuscript and it is hoped that the paper will be completed and submitted for publication by February 1960.

5. Through the Bureau of Commercial Fisheries, Honolulu Biological Laboratory, your secretary has obtained translations of two important Japanese publications on marlins. The translations are by Mrs. Grace Y. Beard and were forwarded by Dr. Donald W. Strasburg. The Committee gratefully acknowledges these persons and the Honolulu Biological Laboratory for this information. These translations are duplicated here as part of the gamefish report so that the information will be more generally available.

APPENDIX I

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Bureau of Commercial Fisheries
Biological Laboratory
P. O. Box 3830, Honolulu, Hawaii

A Population study on the so-called Makajiki (Striped Marlin) of both Northern and Southern Hemispheres of the Pacific - I

Comparison of External Characters[1/]

by

Tadao KAMIMURA and Micao HONMA

English Summary:

The fishes so-called Makajiki (striped marlin) from both of the Northern and Southern Hemisphere of the Pacific have been treated as the same species commercially under the name of "Makajiki".

The authors made a biometric comparison on the external characters of these fishes from the North and South Pacific, for the purpose to determine whether they belong to the same population or to the different.

(1) Following characters were measured by junior author during January and March 1956 at the Fish Market of Tokyo.

I:-Body length:
Distance from posterior margin of eye orbit to median part of caudal fork.

II:-Eye to insertion first dorsal (E.-I.F.D.):
Distance from posterior margin of eye orbit to insertion first dorsal.

III:-Eye to insertion ventral (E.-I.V.):
Distance from posterior margin of eye orbit to insertion ventral.

IV:-Eye to insertion second dorsal (E.-I.S.D.):
Distance from posterior margin of eye orbit to insertion second dorsal.

V:-Eye to insertion first anal (E.-I.F.A.):

1/ Report of the Nankai Regional Fisheries Research Laboratory, No. 8, March 1958. pp. 1-11.

Distance from posterior margin of eye orbit to insertion first anal.

VI:-Length pectoral fin (L.P.F.):
Distance from upper end of insertion pectoral to posterior point of fin.

(2) Relative growths of these portions to the body length are compared, and we find out that there is a remarkable difference on the length pectoral fin between the fishes from the North and South Pacific.

(3) It is assumed that the striped marlins from both of the North and South Pacific are extremely separated situation with each other.

Translation[2/]:

The fishing grounds for tuna longline vessels have been expanding rapidly in accordance with the enlargement of fishing vessels engaged in this activity. At present, the fishing grounds extend to both the North and South Pacific (the Northern and Southern hemispheres of the Pacific) as well as to the Indian Ocean.

A different species* of striped marlin is caught in each ocean. Although there are some external differences by which a specialist can separate the fish, those from the different oceans have previously been treated as a single species commercially, under the name of makajiki (striped marlin), both in the records of vessel operations, as well as in the records kept at the fish market.

In this article, we shall report the result of biometric comparisons of the external characters of fish in order to clarify the relation between the populations of so-called makajiki from the North and South Pacific Ocean.

We express our deep gratitude to Dr. Nakamura, the director of our Laboratory, and Mr. Yabe, chief of Deep Sea Resources Section for instruction and guidance, also to Mr. Shoji Ueyanagi who gave us some very useful advice and to the staff of the Deep Sea Resources Section.

1.--Data

Data were taken from the fish landed at the Tokyo fish Market during January - March 1956, with the measurements being taken by Honma.

2/ Translation from the Japanese by Grace Y. Beard, Bureau of Commercial Fisheries, Biological Laboratory, Honolulu, Hawaii.

* This is only being presumed, and has not been affirmed.

No particular standard was set for the selection of vessels and fish, but an effort was made to obtain the sampling from as wide an area as possible. As for the measuring instrument, a wooden caliper with 1 cm. graduations was used and mm. units were estimated by eye.

The measured parts and the methods of measurement are as follows:

I. Body length: Distance from posterior margin of eye orbit to median part of caudal fork.

II. Eye to insertion first dorsal (E.-I.F.D.).

III. Eye to insertion ventral (E.-I.V.).

IV. Eye to insertion second dorsal (E.-I.S.D.).

V. Eye to insertion first anal. (E.-I.S.D.): Distance from posterior margin of eye orbit to each point of insertion with fins extended from the fish body.

VI. Length pectoral fin. (L.P.F.): Distance from upper end of pectoral fin insertion to posterior point of depressed fin.

Except on some small vessels it is the practice of fishermen to cut off the snout and to eviscerate the fish before storing. Therefore it was not possible to determine the length of snout and sex of the fish measured. Also all measurements were taken from fish with all internal organs removed.

The result of the measurements is shown at the end of this article. The sampling from the North Pacific (the Northern hemisphere of the Pacific) have been classified and arranged into three sea areas, depending upon the actual condition of distribution. Except for the pectoral fin length, only a portion of the data was used for this study. However, for the readers' convenience, we tabulated the measured values of the entire sample.

2.--Method of comparison

A comparison was made of the relative growth of parts of fish to the body length, and an analysis of covariance was used to detect significant differences. However, as shown in the appendix table, we were forced to limit the application of this method, for there was a great deal of difference in body length between the fish caught in the North and South Pacific. In other words, the range of body length of fish caught in the North Pacific was 150 - 200 cm., whereas that in the South Pacific (the Southern hemisphere of the Pacific) was 170 - 230 cm. throughout its subareas. Overlapping distributions between 170 - 200 cm. comprises 1/3 of the range of body length of fish from both the North and South Pacific. Even when sampling is imperfect, there is no problem if the relative growth of each sampling shows the correlation expressed as straight lines on a diagram over the total range of body

length of both sea areas. However, if it does not, the application of statistics becomes very difficult. From this point of view, we examined the linear nature of relative growth. Among the fish from the South Pacific it was recognized that each character showed linear growth, whereas those from the North Pacific particularly showed a non-linear distribution. (However, such a difference was caused by the difference in the range of fish size taken from both areas, and therefore does not actually represent a substantial difference.) The following are considered as the method of actual examination:

a. Compare only the overlapped portions.

b. First determine the range of fish size which would show the linear relation, then make a comparison only within that limit.

(a) has a disadvantage in that the sampling will be greatly limited and use of statistics decreases because the range of examination is extremely limited, although the results obtained will have a high objective validity.

(b) has the advantage of increasing the utilization of the data compared with (a), on the other hand it is so difficult to determine the range of body length accurately that there is a chance that the examination might be performed with some subjectivity.

In this report, (b)-method was used since the data were insufficient. The difference between the regression coefficient and adjusted mean value was examined according to the analysis* of covariance of primary regression. We then gave consideration to the above mentioned statistical weaknesses which are inherent in this method, at the time of consideration of the results.

3.--Comparison between relative growth

On the sampling taken from the North Pacific, the relative growth of each portion to the body length by sea area was studied, according to the sea area division shown in the appendix table. As a result, it was confirmed that the linear relationship on a diagram can be applied to all the samplings which were taken from the area 30°-35°N. and which consisted of the largest size fish. (The linear characteristics was maintained in each case with significance at the 5 percent level.) Therefore first of all, we made comparisons between the specimens taken from 30°-35°N. of the Northern and Southern Pacific. From this we selected those characters which were remarkably different from each other. Then we compared only such characters with the sampling from other sea areas of more detailed analysis.

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* Examination was performed according to Snedecor's method. (1957, Iwanami. Translation by Hatamura and others.)

Figures 1-5 show the relation between the body length and various portions of the body as well as the regression line. Statistics and the results of covariance analysis are shown in tables 1 and 2.

Studying each character except length of pectoral fin in the figures, it is apparent that there are some differences between linear regression in case of E.-I.F.D. and E.-I.V., as well as between the slopes in case of E.-I.S.D. and E.-I.F.A. These are not great differences, however, and a significant difference (at 1-5 percent level) is recognized only in case of E.-I.S.D.; no significant difference is recognized in other cases.

As is obvious in figure 5, in the case of pectoral fin length, a remarkable difference is seen between the position of the regression lines. Since no significant difference is recognized between regression coefficients, the adjusted mean pectoral fin length was determined from the difference between the mean regression (0.14280) and the average body length. The average body length of fish from both sea areas is 188.0 cm., therefore the value is 42.7 cm. in the North and 51.0 cm. in the South Pacific, which means the latter is about 1.2 times the former. In other words, if the range of body length is 150 - 230 cm., the pectoral fin length of the fish from the South Pacific is 1.2 times that of the fish from the North Pacific. As we have mentioned before, since the method of comparison is imperfect, the measurements which show a small amount of difference such as E.-I.F.D., E.-I.V., E.-I.S.D., and E.-L.F.A. are excluded from this study. The following analysis concerns only the pectoral fin length, which shows a remarkable difference.

Figure 6 shows the relation between the pectoral fin length and body length in the samples taken from the North Pacific by sea area, classified according to source by the sea divisions shown in the appendix table. For ease of comparison, the linear regression obtained from the samples taken from the South Pacific is shown separately. Calculation of linear regression and examination of significant difference of each sea area were done as follows: As shown in the figures, not only is the range of body length extremely variable between the sea areas, but also, in the area 18°-25°N. in which is found the smallest size fish, the relation is obviously non-linear. Therefore in this article, the range of body length of fish caught in the area 30°-35°N. was taken as standard, and the minimum was determined to be 150 cm., and calculation was tried on those larger than 150 cm. Furthermore, those marked Ⓐ were excluded from the calculation for the reasons described later. Statistics and the result of covariance analysis are shown in tables 3 and 4.

As shown in the figure, variance which is seen among the sea areas in the North Pacific is much smaller than that in the South Pacific. It is understood that, except for 3 samples which are marked Ⓐ, each variance is located at the lower part of the regression line in the South Pacific. Such a relation shows that no fundamental difference will be caused by including the fish smaller than 150 cm. Referring to the result shown in table 4, no significant difference is recognized among the linear regressions of each sea area, therefore, the variance of this

level is easily obtained in the probability samples from the population of uniform quality.

It is noticed that all three samples marked ⓐ are from the sea area 5°-15°N. Judging from the fact that the number of samples from this sea area was only 15, it cannot be considered that those measured values were obtained by errors in measurement or description, or as a coincidental variance. Since the plotted position was close to the linear regression of the South Pacific, and also this area is geographically very close to the South Pacific, it is proper to presume that these individual fish belong to the South Pacific population.

The facts we have pointed out so far suggest that striped marlin in North and South Pacific can be classified into different morphological populations by the pectoral fin length.

4.--Considerations

Attempts have been made on many species of fish to clarify the internal construction of fish population as resources, by studying the morphological difference of fish in different areas. Reports have been made in the past on yellowfin tuna which is a pelagic fish as is striped marlin, by Godsil (1948), Godsil & Greenhood (1951), Schaefer (1952), Royce (1952), Tsuruta (1954), Tetsu (1957) and etc.* From the results of these studies, the authors presumed that several semi-independent populations exist, since several steps of variations are recognized in the morphological differences in the different areas. Furthermore, they consider the environmental differences at hatching and during growth as the factors responsible for the morphological differences. However, it is obvious that striped marlin in the North and South Pacific belong to different populations, through the different length of pectoral fin, and it seems more reasonable to consider that the difference in pectoral fin length is more a differentiation of a genetic nature than a difference acquired in one generation by environmental influence, judging from the following three points:

1. The difference in pectoral fin length of striped marlin in the North and South Pacific is extremely large.

2. Hardly any difference is recognized among the fish caught in the different areas of the same North Pacific.

3. The North and South Pacific are not considered to be so different in their environment.

We shall discuss this point in Part II of this article, with support from an ecological point of view. At any rate, it is easily deduced that striped marlin in the North and South Pacific form a highly independent population in each area.

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* All are presented under the bibliography section in report II.

Summary

1.) Biometric comparison on the external characters of so-called makajiki (striped marlin) caught in the North and South Pacific, has been made by comparing the relative growth of the following portions of the fish to the body length:

Eye ---- Insertion first dorsal. (E.-I.F.D.)

Eye ---- Insertion ventral. (E.-I.V.)

Eye ---- Insertion second dorsal. (E.-I.S.D.)

Eye ---- Insertion first anal. (E.-I.F.A.)

Length pectoral fin. (L.P.F.)

2.) It is assumed that striped marlin from the North and South Pacific constitute highly independent populations.

APPENDIX II

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Bureau of Commercial Fisheries
Biological Laboratory
P. O. Box 3830, Honolulu, Hawaii

A POPULATION STUDY OF THE SO-CALLED MAKAJIKI (STRIPED MARLIN) OF BOTH NORTHERN AND SOUTHERN HEMISPHERES OF THE PACIFIC - II.* FISHING CONDITIONS IN THE SOUTHERN HEMISPHERE.1/

by

Misao HONMA and Tadao KAMIMURA

English Summary:

The present paper deals with the following problems:

Part I: - Studies on seasonal change of fish condition, length composition and spawning behavior of the striped marlin of the South Pacific (the Southern hemisphere) on the basis of informations furnished by tuna longline fishing boats and of length measurements conducted at the three landing places, Tokyo, Yaizu, Misaki, during the period from April, 1954 to March, 1956.

Part II: - Some considerations on the association between the so-called striped marlins of the North (the Northern hemisphere) and the South Pacific by a comparative study of their distributions, spawning grounds, size compositions and so forth, on the basis of results of the past literatures and of the study in Part I.

Part I: -

1. The fishing ground is formed zonally. It lies east and west covering the area 16°-30°S. The fishing season ranges from August to January, mixing its height between October and November. There is the northward migration during August and November, after then the direction of the migration becomes reversed (figs. 1 - 2).

2. The length compositions of the catch in the main ground are quite simple. The model size is ca. 200 cm. in length, and the feature of the composition never differ remarkably throughout the season (fig. 3).

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*1/ Report of the Nankai Regional Fisheries Research Laboratory. No. 8, March, 1958. pp. 12-21.

3. It may be assumed roughly that the spawning season of the model group ranges from October to the period of its southward migration, though there are a number of uncertain problems.

Part II: -

1. The independence of the populations of both of the North and South Pacific is indicated by the following facts (a - d).

   a. A zone where the hooked-rate is very low lies broadly along the equatorial region as if to separate these two populations (fig. 2, 5, Table 2).

   b. Their main spawning grounds locate very far apart, and moreover, their spawning seasons are in discord half a year with each other.

   c. The maximum size attainable in a life may considerably differ with each other (fig. 2, 6).

   d. Their adaptations to environmental circumstances do not coincide in details, that is, may differ partly through the growth stages.

2. Including together the knowledges of the present and the previous report, it is concluded that the striped marlins of the North and of the South Pacific constitute the extremely separated populations with each other, and furthermore, it is suggested that they may belong to different species.

Translation[2/]:

In the South Pacific (Southern hemisphere of the Pacific), striped marlin has been regarded as one of the important catches by tuna longline since November 1953, when explication of the fishing grounds was extended south of 20°S. In these areas, striped marlin was next in importance to albacore, having enough weight to influence the condition of the formation of the fishing ground.

In this article, seasonal change of fishing condition of the main fishing ground, length composition, and spawning behavior of striped marlin in the South Pacific were studied first. Next, the relation between striped marlin resources of the North and South Pacific was studied on the basis of results of previous studies on striped marlin in the North Pacific (Northern hemisphere of the Pacific) as well as of the morphological comparison presented in Part I.

2/ Translation from the Japanese by Grace Y. Beard, Bureau of Commercial Fisheries, Biological Laboratory, Honolulu, Hawaii

Information provided by tuna longline vessels, and length measurements taken at the three landing places, Tokyo, Yaizu (Nankai Regional Fisheries Research Laboratory, in charge) and Misaki (Kanagawa Prefectural Fisheries Experimental Station in charge), during the period from April 1954 to March 1956, were used for data. Also the length measurements taken by the Daifuji Maru and the Shōyō Maru* were used separately; the explanation will be given where the data are presented.

We would like to express our deep gratitude and appreciation to Dr. Nakamura, the director of the Laboratory and Mr. Yabe, chief of the Deep Sea Resources Section of the Laboratory, for their kind advice, and also to Miss Yoshiko Okamoto for assistance in classification of the data. We also express our appreciation to the members of the Deep Sea Resources Section in the collection of data. Also much useful advice and serious consideration was given us by Mr. Shōji Ueyanagi. We hereby express our thanks to him.

1.--Extent of the fishing ground and seasonal change of fishing condition

The fishing season for striped marlin is from August to January, and throughout the season, no noticeable change in the location of fishing ground is recognized. Therefore, let us examine the approximate extent of the fishing ground according to the chart of fishing condition in November (fig. 1) which is the peak of the fishing season.

As seen clearly in the figure, striped marlin are densely distributed in the sea area south of 16°-18°S., but are seen on the southern edge of the ground of 16°-30°S. from east to west in a continuous line. Because of insufficient data from the area east of 160°W., we only suspect that the situation there is similar to that in the area west of 160°W. Roughly speaking, the area south of 10°S. (including the area densely populated with striped marlin) is mainly the fishing ground for albacore, and the area north of 10°S. is mainly for yellowfin. Among the fishermen, the former is called "albacore and striped marlin fishing ground", but in this article it will be called simply "striped marlin fishing ground".

Figure 2 shows the seasonal change in the catch rates. The area with relatively complete data is subdivided by 10° of longitude. Changes by season and latitude in each area are shown in the figure.

As a rule, similar tendencies are apparent in the seasonal changes through each sea area. The following are some of these tendencies in detail:

Daifuji Maru - - Research vessel of Shizuoka Prefecture (472 ton).

Shōyō Maru - - - Research vessel of the Fisheries Agency (602 ton).

a. The catch rate is highest in October and November, gradually decreasing before and after this season.

b. The north edge of the area with high catch rate, in other words the northern edge of the "striped marlin fishing ground", is located in the extreme north during October and November. In the season before and after October and November, the northern edge gradually moves southward.

c. The catch rate is very low throughout the year in the area north of 16°S. especially in the area north of 10°S. where there is hardly any worthwhile catch.

Generally speaking, the catch rate is higher in the western area and low in the eastern area. However, this tendency is not particularly noticeable.

The phenomena described in (a) and (b) are considered to be caused by southward and northward migration of fish schools, making October and November the turning point; presumably northward migration occurs before this season, and southward migration after this season. It is understood that the best season for striped marlin fishing is during October and November when the fish schools migrate the farthest north, therefore it is considered most appropriate to include the period immediately before and after, this in other words August - September and December - January as comprising the fishing season for striped marlin.

Also judging from (c), it is presumed that fish do not migrate as a school north of 10°S. during their northward migration. We shall discuss this point later as it supplies an important clue for consideration with respect to their association with striped marlin from the North Pacific.

Data on fishing condition were obtained from the area south of 30°S. nearly to 35°S. According to the available data, the fishing condition does not seem to be as active as in the area north of 30°S. however, details are not clear because of insufficient data.

2.--Size composition

Figure 3 shows the seasonal change of size composition* of striped marlin caught in the "striped marlin fishing ground" during the 1954 and 1955 seasons. Since no significant difference was recognized in the east and west, or south and north sections of the fishing ground, the complete data were arranged by season. As seen in the figure, hardly any change in the size composition occurred in any season, but instead there was a simple composition, having its mode at about 200 cm., through all seasons. The 200 cm. size is extremely large for striped marlin. We

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* Body length is the distance from the posterior margin of the eye orbit to the median part of the caudal fork.

shall discuss this later. Not only was the size composition simple, but also there was noted very little change by location or season. This shows that the schools on the fishing ground, size of the fish is almost uniform regardless of location or season, and seems to support the idea of a simple migration of schools northward and southward as mentioned before.

Figure 4 shows the size composition of those striped marlin occasionally caught in the water north of the fishing ground, in other words in the area between 16°S. and the equator. Since that data were so few, the area was roughly divided in two; one area 5°-16°S. and the other area 5°S - 5°N.* The data represent all fish measured during the period from April 1954 to March 1956. Although details are not clear, the tendency is that, in comparison with the "striped marlin fishing ground", the number of the smaller size fish is greater. It is also noticeable that fish about 100 cm., which seem to be immature fish, were caught in waters north of 5°S.

However, it is open to discussion whether or not those immature fish belong to the same population in the South Pacific.

So far, we have outlined the size composition of fish caught in the whole area of operation. It is noticeable that in comparison with the large size fish, the frequency of medium and small size ** fish is extremely small***. Excluding small size fish, whose catch is easily influenced by selection of fishing gear and method, medium size fish from the main catch in the North Pacific, (Ueyanagi, 1954), and the reason for medium fish being so scarce can hardly be considered to be influenced by selection of gear and method. It is proper to consider that the medium fish are distributed outside of the fished area. This is worth considering when an exploitation program for the new fishing ground is planned.

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* The area 5°N. was included for convenience in classification of the data according to vessel, since a considerable number of vessels in adjacent equatorial waters perform operations covering several degrees of area in both Northern and Southern hemispheres, on both sides of the equator.

** For easier explanation, we shall call the fish school with the mode at about 200 cm. the "large size" group, the presumably immature fish of about 100 cm. or similar to this size the "small size" group, and those in-between the "medium size" group.

*** We want to point out that fish smaller than those caught in the "striped marlin fishing ground" increased in proportion in the area north of 16°S. At any rate, the result does not show that the medium size fish are not in balance with the large size fish in quantity. This can be easily understood by comparing the catch rates in the "striped marlin fishing ground" which is occupied by the large size group with those of the area north of 16°S; or from the fact that the large size group shows the higher rate than medium size group, in the size composition of fish from the area north of 16°S.

3.--Spawning behavior

Table 1 shows the frequency distributions of ovary weight, according to the investigation conducted by the Shōyō Maru (Sept., Oct.) and the Daifuji Maru (Dec., Jan.) in the "striped marlin fishing ground". According to the explanation by Ueyanagi (Shōyō Maru), Honma and Mimura* (Daifuji Maru) who participated in this investigation, it is permissible to consider all ovaries below 500 g. immature, 500-2,000 g. early mature, 2,000-5,000 g. medium mature, and above 5,000 g. mature. During the investigation by the Daifuji Maru, they observed ovaries apparently in the spent stage, and the number of these is also included in the weight columns.

Studying the maturity of the ovary according to the frequency distributions of ovary weight, a great development occurs from September - October to December - January. In September and October, they are presumed to be in the pre-spawning condition, and in December and January, they are regarded as post-spawning. The situation after January is unknown, and also that data on fish smaller than medium size are insufficient, Therefore a detailed discussion is not possible, but for the large size fish in the "striped marlin fishing ground", at least, it is presumed that there is a relatively distinct spawning period, and December and January are included in this period.

Nomura (1955) quoted Mr. Nobuo Tanaka of No. 12 Marutaka Maru saying, "striped marlin which migrate northward in the Coral Sea during fall seem to be of the spawning group. During September and October, those in the pre-spawning condition are caught. Spawning is over by December, and 90 percent of the ovaries are in the spent stage. The spawning period seems to be about November." The Coral Sea discussed here is the southern part of the Coral Sea, and he probably meant the striped marlin fishing ground adjacent to the continent of Australia. Although data are not sufficient for a detailed discussion, providing the presumed sea area mentioned above is correct, the difference in estimation of spawning period must be mainly caused by the difference in sea area (refer to the investigated sea area in table 1). At any rate, the differences regarding the estimation of the spawning period do not substantially contradict each other.

It is noteworthy that two periods regarded as the spawning season happen to be the season for the southward migration, and include the transition period when the migration changes from northward to southward. At the present stage of investigation, nothing definite can be said. As for the rough estimation, there will not be any serious mistake in regarding October and November as the transition period in the direction of migration, and the period of southward migration thereafter as being the main spawning season of the large size fish.

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* All are staff members of Nankai Regional Fisheries Research Laboratory.

According to Nakamura (1937, 1949, 1951), Nakamura and others (1953), and Ueyanagi (1954, 1957), the estimated spawning period of striped marlin in the North Pacific is from April to June. Considering that there is a six month difference in season between the North and South Pacific, the spawning period of the above mentioned large size fish in the South Pacific and striped marlin in the North Pacific coincide seasonally.

4.--Considerations on the association between the striped marlins of the North and South Pacific.

We have reported in Part I of this article that striped marlin caught in the North and South Pacific belong to different populations as the result of morphological comparison. In this article, we will continue our study by comparing their ecological differences.

Before discussing this, we will present a summary of the items which seem to be necessary to our knowledge of striped marlin from the North Pacific.

a. Distribution and movement: Nakamura (1941, 1951) mentioned, according to prewar data, that striped marlin are most abundantly distributed in the subtropical areas of the central Pacific to latitude 40°N. Ueyanagi (1954) reported from additional postwar data that the fishing grounds in the central Pacific are divided into two parts: one formed in the area north of 30°N. (the northern ground) in fall and winter, and the other formed in the area 20°-30°N. (the central ground) during spring and summer. It is characteristic that in the former ground the fish migrate southward and in the latter ground they migrate northward. He mentioned that the density of fish population in the area 10°-20°N. is relatively high, but that it is very low in the area 0°-10°N. throughout the year (figure 5).

b. Size composition: (fig. 6). Ueyanagi also noted that the dominant size group is composed of fish of 140-170 cm., although this differs by area. It was noticeable that the small size fish of presumable immature groups appeared in the area 10°-20°N, but the details were unknown. Furthermore, Nakamura (1954) and Ueyanagi (1954) made it clear that this phenomenon is closely connected with the current system, then made a presumption that this phenomenon is caused by an ecological area-selection for growth, spawning, and feeding. Their conclusion is that according to the above-mentioned reasons, the fish in different areas are closely related as a resource.

c. Spawning: Nakamura (1937, 1949, 1951) stated that in the adjacent seas of Formosa, April - May is the spawning period. Ueyanagi (1954, 1957) stated with regard to striped marlin in the central Pacific that the group of fish in the central fishing ground which migrates northward in spring and summer must be the main spawning group.

The following are examples to show that striped marlin caught in the North and South Pacific are independent populations; the comparison is derived from the summary on striped marlin in the North Pacific and

the data listed in paragraphs 1-3 on striped marlin in the South Pacific:

a. As shown in fugures 1 and 2 as well as in (a), above the main fishing grounds of the North and South Pacific are separated by a wide area on both sides of the equator which can be ragarded as a vaccuum zone of catch.

b. As stated in 3 and (c), the main fishing grounds are greatly separated, and in addition the spawning periods are six months apart.

c. As obviously shown in figures 3 and 4, and in comparison to the size composition in fugure 6, the large size fish of about 200 cm. form the main group in the South Pacific, whereas a group of this size is hardly ever seen in the North Pacific, and particularly with regard to the area north of 10°N. where those larger than 200 cm. are not even recognized as a group.

d. There is a great difference in the distribution of the medium size fish by sea area. In the area north of 30°S. in the South Pacific, the medium size fish were very rare (figs. 3-4), whereas in the area south of 30°N. in the North Pacific, which corresponds to the above mentioned area, the density of distribution of the medium fish is so high that they form the main catch (figs. 5-6).

The facts stated in (a) and (b) show that striped marlin in the North and South Pacific respectively represent independent populations. Together with the morphological difference pointed out in Part I, this shows that fish in the two areas are in a highly separated condition. In order to make this point clearer, the frequency distribution of catch rate by season in the equatorial region 5°S - 5°N. is shown in table 2. Since this table is based on catch rate data, it can not support conclusions concerning small size fish, for these are easily influenced by selection of fishing gear or method; however, it is considered a support for the assumptions concerning large and medium size fish. As seen in the table, the occurrence of no-catch is 98 percent of the season, and adding the 0.1 percent catch to this, it totals over 98 percent. Judging from these facts, it seems permissible to consider that the large* and medium size fish groups are, if not perfectly separated, very close to that condition.

About (c): Considering that the North Pacific has been exploited for many years it can be presumed, that the fish size as a whole is becoming smaller, being influenced by fishing. However, judging from the following reasons, it is rather difficult to determine if the influence of fishing is the direct cause of this difference: (1) In the North Pacific, there actually was a period when no fishing operations were performed, such as during the time of World

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* From the result of studying morphology, a similar situation can be presumed for the small size fish groups as exists in the large or medium size groups.

War II until several years after the end of the War. (2) The size composition shown in figure 6 is based on the data which were obtained after 1948 not too long after the end of the War. (3) Fish larger than 200 cm. are hardly ever seen in size compositions from the eastern section of the North Pacific which has been exploited very recently. (Ueyanagi, unpublished). The maximum size differs between those fish from the different sea areas. It is apparent that striped marlin in the South Pacific reach larger sizes than those caught in the North Pacific. This fact shows that the ecological characteristics concerned with maximum size must be different between the two groups of fish.

About (d): Since the sea area where the medium size group of the South Pacific is mainly distributed is not clear, a detailed discussion should be postponed. However, it shows that reaction of the fish toward the environment differs according to the stage of growth of the fish.

The facts stated in (c) and (d) together with the biological significance of the difference in length of pectoral fin which was discussed in Part I, show that striped marlin caught in the North and South Pacific are in a considerably differentiated condition.

It is understood that striped marlin from both the North and South Pacific form schools widely separated from each other as resources, and it is also conceivable that they are differentiated as species from the above summary and the results of the study introduced in Part I. Therefore it will be necessary in the future to confirm this point by taxonomical research work.

By classifying and examining reports presented in the past about Makaira caught in various areas of the Pacific, Indian and Atlantic Oceans F. R. La Monte (1955) decided that the only species of so-called striped marlin in the Pacific was Makaira mitsukurii (Jordan and Snyder). However, this study was not based on the analysis of detailed data. Therefore there is considered to be more room for future study.

Summary

The following points have been clarified as the result of a study on the seasonal change of fishing condition, size composition and spawning behavior.

1). The fishing ground is formed in the area 16°-30°S. from east to west. The fishing season is from August - January. The fishing ground moves farthest north in October and November, which are the best fishing months. The fish schools migrate northward from August and September to October and November, and migrate southward after these periods.

2), The size composition of fish caught in the "striped marlin ground" (16°-30°S.) shows a simple length composition with a mode at about 200 cm. There is hardly any variation by area or season.

3). Although there are still many unknown points about spawning behavior,

the spawning period of the large size fish is roughly estimated to be from October and November to the period of southward migration.

4). The following were pointed out concerning the relationship between striped marlin from the North Pacific and those from the South Pacific:

a. A zone of very low catch exists broadly from east to west with the equator in its center.

b. The spawning areas are greatly separated and the spawning periods are six months apart.

c. The maximum sizes differ greatly.

d. The ability to adjust to the environment differs depending upon the stage of growth.

Thus, we suggest that fish from the North and South Pacific are under widely diverse conditions, and also that they are differentiated as species, from the above mentioned points and the summary of study in the morphological difference stated in Part I of this report.

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